Water Pollution Assessment of Selected Valuable Rivers in Efon Alaaye, Ekiti State

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Abstract- Pollution in relation to river water is the term used to express the level of contamination and the suitability of such river water to sustain various usage. In many developing countries, the main issue, however, is not the physical scarcity of water but poor management which results in the continuous deterioration of water quality. This study conducted an onsite measurement of seasonal stream flow and quality variation of major valuable streams use for non-potable domestic purposes in Efon-Alaaye, Ekiti state. Stream flow data was obtained using volumetric method and the quality analysis was carried out in accordance with Standard Methods for Examination of Water and Wastewater. The result shows that the average stream flow ranges from 0.120 m^3/s to 1.04 m^3/s. The physicochemical parameters measured fall short of the national and international standards, which indicates that the water is not fit for human consumption. It was also observed that the self-cleansing of the studied rivers is sufficient to meet the quality requirement for non-potable domestic use. It is recommended that all human activities that could lead to further pollution should be avoided around the river catchment while period public enlightenment should be carried out to sensitize the community on the best hygienic practice within the river catchment to promote good water quality.

Keywords- Water quality, water pollution, stream flow, water management.

1 INTRODUCTION

River pollution is affected by a wide range of natural and human influences. Notable natural influences are geological, hydrological and climatic. Although natural ecosystem is in harmony with natural water quality, any significant changes to water quality will ultimately disrupt the ecosystem. Human intervention also has huge effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities such as the discharge of wastewaters into the water course (whether intentionally or accidentally) (UNEP/WHO, 1996) and poor sanitation practices (Guiteras et al., 2015).

Rivers are important sources of natural water apart from serving as a source of drinking water, irrigation and fishing, they are generally of immense importance in geology, biology, history and culture. They are vital carriers of water and nutrients to areas all around the earth .The effect of pollution on river water depends both on the nature of pollutant and unique characteristics of the river. Some important characteristics include volume and velocity of water flowing in the river, river depth, type of sand bed and surrounding vegetation (Anhwange et al, 2012). Other factors include the climate of the region, the mineral heritage of the watershed, land-use pattern and the type of aquatic life in the river (UNEP/WHO, 1996). Global attention in the past and more recently has been focused primarily on water quantity and allocation issues, poor water management has created a serious problem in terms of quality in many parts of the world. Biswas and Tortajada (2011) reported that while developed countries have made significant and commendable progress in controlling point sources of pollution during the past three to four decades, commensurate progress has simply not occurred in developing countries. Thus if a future water crises develops, it will be due not to the physical scarcity of the resource, but because water quality is steadily deteriorating in most developing countries.

Agbaire (2009) stipulated that water bodies (i.e. rivers, streams and lakes) are constantly used as receivers for untreated wastewater or poorly treated effluents accrued from industrial activities in many developed countries. This may render water bodies unsuitable for both primary and/or secondary usage. One of the most critical crises in developing counties is the lack of adequate potable water. State of Environment Report (2008) submitted that as water quality degrades, the range of potential uses decreases. Many elements of the environment affect river water quality. For example, land clearing for agriculture and urbanization has led to major catchment–wide changes, including erosion and salinity. Climate change will modify existing pressures on water quality. Malaj et al. (2014) investigated the sources and risks of organic chemicals in freshwater biodiversity in 4000 European sites. They reported that this pollution was traced to agricultural sites and urban areas in the upstream catchment of the freshwater with increased risk of potential acute lethal and chronic long-term deterioration in the quality status of fish and invertebrate communities.

Biswas and Tortajada (2011) in their view argued that water quality management is significantly more complex than water quantity management. They therefore submitted that for water quality management, the type of data required varies with time, geographical locations, nature of pollutants being discharged or likely to be discharged, and their potential impacts on human health and the environment, as well as a variety of other factors. The objectives of this study are to assess the water quality of valuable streams use for domestic purposes in Efon Alaaye, Ekiti State through analysis of some selected water quality parameters and compare the result with national and international water quality standards.

2 Research Methodology

2.1 Description of the Study Area

Efon – Alaaye is located on longitude 7°40′48"N and latitude 4°48′54"E (Fig. 1). It is bounded round by chains of ridges rising to an average height of about 500meters above the sea level. It is situated in a valley that spreads over an area of about 136 square meters. (Oyedele, 2010). Efon – Alaaye is the gateway to Ekiti State from Ilesha (Osun State) and its affinity with Ekiti is more on the geographical location than its cultural traits. It falls within the humid tropical zone characterized by the wet and dry climate. It enjoys relatively heavy rainfall annually (March - October) which is characterized by thunder storms. Efon is drained by many streams and rivers from the surrounding hills. They are dependable even in dry season because they never dry up completely. Two of such rivers are historically significant for they are believed to be of medicinal value which the people consider as divine blessings bestowed on them. River Olua is believed to be capable of healing victims of guinea – worm, while River Oni is also believed to possess elements of divine healing to the sick and capable of washing off misfortune in anybody who bathes in it after the Late Apostle J.A Babalola of Christ Apostolic Church (C.A.C) fame had blessed it. These two miraculous rivers attract people from diverse areas of Yoruba land to Efon – Alaaye. (Adeoti, 2013).

2.2 Streamflow Measurement

This was done via Volumetric method which is based on the continuity equation, $Q = A \times V$. Some of the apparatus/tools often used for measuring streamflow include a measuring tape, floatable object (orange peel), timer and a data sheet. The following activities were carried out sequentially as proposed by Rantz (2007):

i. Selection of site: A fairly straight stretch of the river where the water flow is almost uniform with a relatively flat bottom is selected for each of the rivers.
ii. Measure a two meter (2m) length of the stream along the selected site with a relatively uniform width. Mark the starting point and end point of the measurement with flags.
iii. Determine the width of the river at the starting point, the end point and at a point midway between these two points for a total of three width measurements. Calculate the average width and record the value in the data sheet for each river.
iv. Measure the depth of the river along each width line with the use of a yardstick. When taking the measurement, do not push the yardstick into the streambed sediment and keep the yardstick vertical for each measurement. Compute the average value of the measurements and record as appropriate.
v. Drop the floating object into the river. Begin the timer once the floating object has reached the beginning point. Stop the timer when the float gets to the end point. If the object becomes lodged and stuck in an eddy, the procedure should be repeated. The time it takes the float to drift from the starting point to the ending point should be noted. This process should be repeated about three to four times (3 - 4) with the average time noted and recorded.
vi. Multiply the average width by the average depth so as to obtain the cross sectional area (A) of each stream.
vii. Compute the velocity of the flowing water by dividing the length of the measured section by the time it takes for the floating object to move across the measured section.
viii. Multiply the velocity by the area to obtain the streamflow. To obtain a final adjusted streamflow, multiply the streamflow by a factor (n = roughness of the streambed). For streams with smooth bed, use 0.09, while for streams with a rough bottom, use 0.08. Record all computed values on the data sheet.

Fig 1: Map of Efon Alaaye

2.3 Physicochemical and Microbial Analysis

Water samples were collected using appropriate techniques and were kept in sterilized sample bottles. After collection, the samples were placed in cooler boxes with ice chests while being transported to the laboratory and kept at about 4°C until they were analyzed. Most parameters including some microbiological components were analyzed within 24 hours. All chemical analyses were done at least in duplicate. Non conservable parameters such as pH, temperature and electric conductivity were determined insitu on the field. The pH was measured with a pH meter previously calibrated with buffer solution. Temperature was measured with thermometer, while conductivity was measured with a conductivity meter calibrated with potassium chloride solution. Chemical properties analyzed include alkalinity, total hardness, chloride content, dissolved oxygen and bio-chemical oxygen demand, while biological properties determined are Escherichia coli and total coliform. Samples for chemical and microbiological analyses were analyzed according to standard procedures enumerated in APHA (1995), DWAF (1996) and UNEP/WHO (1996). Samples for trace/heavy metal analyses were preserved with 5 m/L concentration of

HNO3. The presence of heavy metals was conducted using an Atomic Absorption Spectrophotometer (AAS, buck Scientific Model 2010). Elements measured are Manganese, iron, copper, zinc and lead. Samples were taken at the end of the raining season (December) and all analyses were carried out accordingly/respectively.

3 Results and Discussion

Streamflow measurement can yield information on changes in discharge that are valuable for predicting flooding, estimating long–term trends in water and sediment discharges, and for distinguishing possible long-term climate change (Turnipseed and Vernon, 2011). By measuring streamflow, the ability of the river to support life can be determined. Water temperature, levels of dissolved oxygen and turbidity are affected by streamflow. The temperature of water in slow flowing, shallow rivers tend to be warmer than that of deeper, faster flowing rivers. Faster flow of water can cause increased erosion of river banks which may result in elevated levels of turbidity. Thus, the rate of flow determines the conditions of the water, which determines the types of plants and animals living in and around the river. Table 1 shows the flow rate of available water bodies in the study area.

From Table 1, it can be said that the flow rate is a specific function of the depth and width of the river. River Ita-awure which has the highest flow rate of $1.04m^3/s$ has the highest depth (1.3 m) and significant width (2.5 m). It has a smooth streambed and the water can be said to have high turbidity (305 NTU) due to erosion of the stream banks as the water flows through the stream. River Babalola possess similar characteristics. River Babalola is linked by a lined drainage that convey runoff from the town into the stream on the upstream side. This generates a sort of eddy which enhances the absorption of oxygen and invariably increases the dissolved oxygen content of the stream. River Oni has its upper course lined, while the middle course is filled with protective vegetative cover. It has smooth/ fine sand streambed, and it is characterized by free flowing clear water. River Afeni and River Orooro possess rocky/coarse streambed. Water movement in these rivers can be termed as gentle uniform flow, gradually flowing out of the rock cracks/faults. They are characterized by low depth and low turbidity owing to the type of flow. The stream bank of river Olua is bare and subject to water erosion. It is characterized by large width and shallow depth.

3.1 Physico-chemical Properties

The provision of drinking water that is not only safe but also acceptable in appearance, taste and odour is of high priority. Water that is aesthetically unacceptable will undermine the confidence of consumers, lead to complaints and, more importantly, possibly lead to the use of water from sources that are less safe. Table 2 present the results of the physico-chemical analysis conducted on the river samples.

i. **pH, Alkalinity and Corrosion** - Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. The optimum pH range is 6.5–8. For effective disinfection with chlorine, the pH should preferably be less than 8; however, lower pH water is likely to be corrosive. Extreme values of pH can result from accidental spills, treatment breakdowns and insufficiently cured cement mortar pipe linings or cement mortar linings applied when the alkalinity of the water is low. Alkalinity and calcium management also contribute to the stability of water and control its aggressiveness to pipe and appliance. Failure to minimize corrosion can result in the contamination of drinking water and in adverse effects on its taste and appearance. (WHO, 2006). Results obtained indicated that all rivers investigated fall within the stipulated alkalinity and pH range except for River Afeni that has a pH value of 6.1, which suggest the presence of inorganic metals, while River Ita-awure has the highest alkalinity value of 92mg/L which is tolerable.

ii. **Temperature-** Cool water is generally more palatable than warm water, and temperature will impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of micro-organisms and may increase taste, odour, colour and corrosion problems. (WHO, 2006). Temperature value measured and recorded for all the streams investigated fall relatively below the WHO maximum limits.

iii. **Conductivity**- Electrical conductivity is a useful indicator of mineralization and salinity or total salt in water sample. According to Muhibbu-din et al. (2011), electrical conductivity increases with increase in total dissolved solids. High conductivity reflects the pollution load as well as tropic levels of aquatic body (Anhwange et al., 2012). DWAF (1996) indicated that conductivity values below 50 μs/cm are regarded as low, while those between 50-600 μs/cm are said to be medium and values above 600 μs/cm are considered to be high. Samples examined have low to medium conductivity. River Afeni has the highest value of conductivity. This shows the heavy presence of minerals which invariably can be traced to the source of the river since it takes it root from a fractured rock.

iv. **Total Dissolved Solids** - Total dissolved solid is a measure of inorganic salts, organic matter and other dissolved materials in water. Changes in total dissolved solids levels in natural water often result from industrial effluent or salt-water intrusion (Phyllis et al., 2007). The concentration and composition of total dissolved solids in natural water is determined by the geology of the drainage, atmospheric precipitation and the water balance. Total dissolved solids causes toxicity through increase in salinity and changes in the ionic compositions of the water. The palatability of water with a TDS level less than 600 milligram per liter is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 milligram per liter. Results obtained suggested that rivers examined for TDS level all for below the set maximum limits, except for River Afeni with a significant value of 1,100 mg/L. this may not be suitable for direct consumption, hence, it can be used to meet other demands other than direct consumption without adequate treatment.

v. **Turbidity** - Turbidity in drinking water is caused by particulate matter that may be present from the source of the water as a consequence of inadequate filtration or from resuspension of sediment in the water system. Turbidity is also a particular function of the streamflow and stream bank conditions. The higher the velocity of flow, the more likely the increases in turbidity, especially for surface water flow with bare stream bank area. The appearance of water with turbidity less than 5 NTU is usually acceptable to consumers, although this may vary with local circumstances. River Orooro, Babalola, Ita-Awure and Olua all have a turbidity value in excess of the tolerable limit. This is due to the fact that measurements were made during the peak raining season when runoff freely runs into the rivers.

vi. **Hardness** - Hardness caused by calcium and magnesium is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. Depending on the interaction of other factors, such as pH and alkalinity, water with hardness above 200 mg/L may cause scale deposition in the treatment works, distribution system and pipe networks and tanks within the buildings. It will also result in excessive soap consumption and subsequent 'scum' formation. On heating, hard waters form deposits of calcium carbonate scale. Soft water, with hardness less than 100 mg/L, may, on the other hand, have a low buffering capacity and so be more corrosive for water pipes (WHO, 2006). All rivers observed fall below the maximum limits which makes them suitable for a wide range of operations.

vii. **Chloride Content** - High concentration of chloride gives a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200-300 mg/L for sodium, potassium and calcium chloride. Some concentrations in excess of 250 mg/L are increasingly likely to be detected by taste, but some consumers may become accustomed to low levels of chloride-induced taste (WHO, 2006). The chloride content of the streams investigated is lesser than the tolerable limits.

viii. **Dissolved Oxygen** - The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical or biological processes taking place in the water system. Depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulphide. It can also cause an increase in the concentration of ferrous iron in solution, with subsequent discoloration at the tap when the water is aerated. River Oni, Babalola and Ita-Awure have high dissolved oxygen value of 26.1, 24.2 and 23.1 mg/l respectively. This can be attributed to their significant flow rates. The movement of water molecules helps in trapping more oxygen within the water system.

ix. **Bio-chemical Oxygen Demand** - Biochemical oxygen demand is a measure of the quantity of oxygen used by micro-organisms (e.g. aerobic bacteria) in the oxidation of organic matter. (Anhwange et al 2012). Increase in biochemical oxygen demand may be due to increase in urban runoff which carries pet wastes from streets and sidewalks; nutrients from fertilized lawns; leaves, grass chippings, and refuse from residential areas into the river. Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen needed to live. Rivers with low biochemical oxygen demand have low nutrient levels and this implies high concentration of dissolved oxygen. The lower the biochemical oxygen level, the more suitable the water is for human usage. Wen et al. (2017) quantified global sanitation crisis through impact on organic river pollution from threats of wastewater discharge from urbanization and increase livestock farming together with reductions in river dilution capacity due to climate change and water extraction using in-stream BOD as an overall indicator of organic river pollution. The biochemical oxygen demand of the streams observed are in the range of 21.2 to 26.1 mg/l

3.2 MICROBIAL ANALYSIS

The human health effects caused by water borne transmission vary in severity from mild gastro-enteritis to severe and sometimes fatal diarrhea, dysentery, hepatitis and typhoid fever. The results of microbial analysis of the studied rivers are shown in Table 3.

i. **Total Coliform** - Total coliform bacteria include a range of aerobic and facultative anaerobic, gram-negative, non-spore-forming bacilli capable of growing in the presence of relatively high concentration of bile salts with the fermentation of lactose and production of acid or aldehyde within 24hours at 35-37°C. The coliform bacteria (excluding E. coli) occur both in sewage and natural waters. Maximum tolerable limit of Total Coliform is given as 10 cfu/100mL. All the rivers examined fall below this limit, with river Ita-awure having the highest value of 4.6 cfu/100mL. This suggests that minimum treatment is required to make the water essentially safe for consumption.

ii. **Faecal Coliform Counts** - The presence of E. coli provides evidence of faecal contamination, and detection should lead to consideration of further action, which could include further sampling and investigation of potential sources (WHO, 2006). WHO recommends zero tolerance limit for water polluted with faecal coliform, stating that water contaminated with E. coli should not be consumed. Of the 6 rivers considered in this study, two rivers are contaminated with E. coli. River Afeni and river Olua contains a significant amount of E. coli. Hence, they should not be used for domestic purposes without treatment. Control measures that can be applied to manage potential risk from E. coli include protection of raw water supplies from animal and human waste and adequate treatment.

Table 1. Results of Streamflow of Major valuable Rivers in Efon Alaaye

Rivers	L (m)	B (m)	D (m)	t (s)	*n	A (m2)	V (m/s)	Adj. V (V × n)	Streamflow (m3/s)
River Oni	2.0	2.4	0.8	0.4	0.09	1.92	5.00	0.450	0.864
River Afeni	2.0	2.0	0.4	1.2	0.09	0.80	1.67	0.150	0.120
River Orooro	2.0	2.1	0.6	1.4	0.08	1.26	1.43	0.114	0.144
River Babalola	2.0	2.1	1.2	0.6	0.08	1.47	2.86	0.230	0.338
River Ita-awure	2.0	2.5	1.3	0.5	0.08	3.25	4.00	0.320	1.040
River Olua	2.0	3.1	0.4	1.0	0.09	1.24	2.00	0.180	0.223

L = Length, B = Breadth, D = Depth, t = Time, *n = roughness of the streambed, A = Area, V = Velocity and Adj. V = Adjusted Velocity.

Table 2. Physicochemical Properties of Selected Surface and Ground water in Efon-Alaaye

Parameters	A	B	C	D	E	F	WHO (2006) Maximum Limit	SON (2007) Maximum Limit
pH	6.5	6.1	6.8	7.1	7.2	6.7	6.5-8.5	6.5-8.5
Temperature (°C)	23.0	24.0	24.0	23.5	23.0	23.5	30-35	*N/A
TDS (mg/l)	90	1100	90	250	430	270	500-1000	*N/A
Turbidity (NTU)	4.33	0.62	7.10	139	305	175	5.0	5.0
Conductivity (μS/cm)	42.0	224.0	22.0	52.0	88.0	56.0	1000	*N/A
Alkalinity (mg/l)	16	12	8	44	92	48	200-600	*N/A
Total hardness (mg/l)	6	33	3	16	33	18	100-200	150
Chloride content (mg/l)	60	20	70	60	46	57	200-300	250
DO (mg/l)	26.1	21.4	20.1	24.2	23.1	21.2	*N/A	*N/A
BOD (mg/l)	26.5	22.2	21.4	25.4	24.3	22.1	*N/A	*N/A

Note: *N/A = not available, A is river Oni, B is river Afeni, C is river Orooro, D is river Babalola, E is river Ita-Awure, F is river Olua, G is Ojodi borehole,H is Oniyo borehole and I is Ita-Awure borehole.

Table 3. Microbial Loads of Major Rivers in Efon – Alaaye

Parameters (cfu/100ml)	River Oni	River Afeni	River Orooro	River Babalola	River Ita-awure	River Olua	WHO Maximum Limits
Total Coliform Counts	3.4	4.5	1.2	4.2	4.6	4.1	10
Faecal Coliform Counts	0	1.0	0	0	0	1.2	0

*N/A = Not available

4 CONCLUSION

Maintaining good water quality is vital to ensure serene natural systems and wellbeing. (State of Environment Report, 2008). Some of the physico-chemical, microbial and metallic constituents measured in the selected rivers fall short of the national and international standards, which indicates that the water is not fit for human consumption. It was also noted that, a positive correlation exists between the flowrates of the studied streams and the dissolved oxygen content.

5 RECOMMENDATIONS

Based on the research conducted, the following practices are recommended;

i. Land area surrounding the river should be covered with vegetation so as to reduce streambank erosion. When streambanks are protected, turbidity, alkalinity and colour of the flowing water are better managed, and hence water quality is improved.
ii. Grazing activities should be discouraged in areas relatively close to the rivers. This will help in preventing long term deterioration of the microbial composition of surface water.
iii. Human activities such as washing of cars, components and house-hold accessories, disposal of hazardous chemicals to water bodies should be discouraged, while commensurable punishments be allotted to defaulters. This will help in the management of the chemical properties of the river water.
iv. Laws for surface water management should be enacted and implemented with sincerity and seriousness. This will reduce the level of pollution and consequently reduce the cost associated with water treatment.
v. Stream gauging should be done regularly and particular attention must be given to climatic conditions so as protect community members and the environment from environmental hazards which may be in form of flooding, water lodging of valuable farmlands and water pollution.

vi. Continuous education and periodic awareness campaign should be carried out to educate users on their roles in in protecting water sources. To also enlighten them on their habits and cultural practices that may pollute water sources and dangers of poor water quality to their health.

ACKNOWLEDGEMENT

The author is grateful to Mr. Ilori Boluwatife, a Master of Engineering student of the Department of Civil and Environmental Engineering, Federal University of Technology, Akure for his valuable contribution to data gathering.

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